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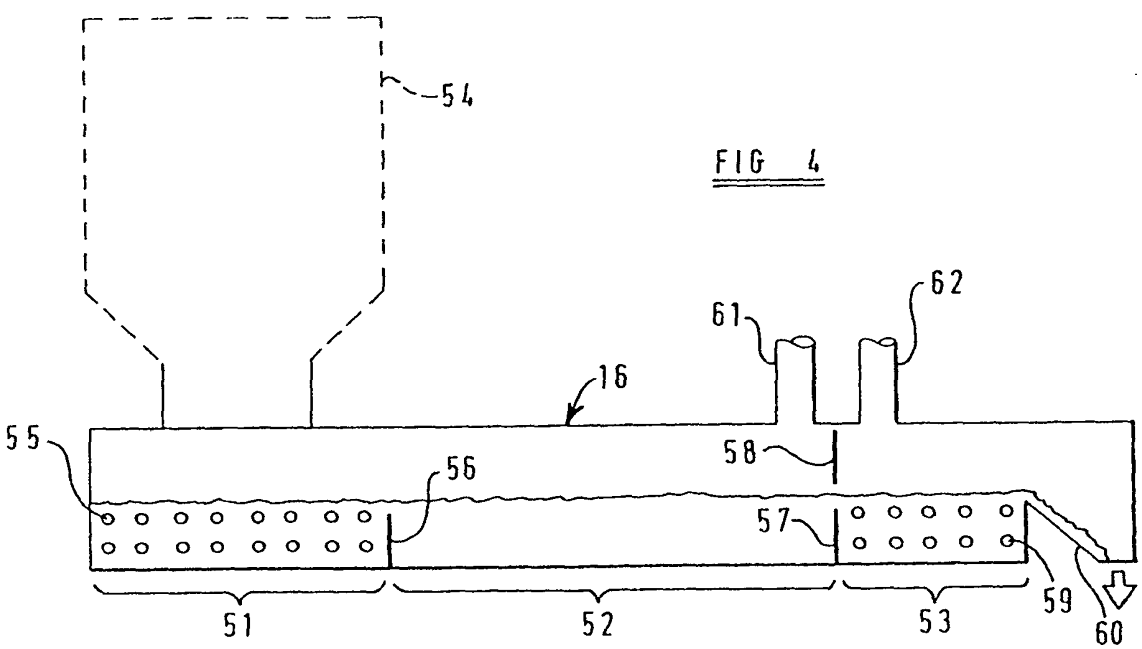
GB 1457479 EP 0089927

(58) Field of search
B1F
B3G
F4U

(54) **Casting Metal and Reclaiming Foundry Sand**

(57) Used foundry sand containing an organic binder is reclaimed by separating the sand from a casting, supplying the sand to a fluidised bed, fluidising the sand in the fluidised bed with combustion supporting gas introduced at several locations so that the sand remains in a fluidised state at an elevated treatment temperature, and removing reclaimed sand from the fluidised bed. Apparatus for reclaiming used foundry sand may comprise three communicating fluidised bed sections 51, 52, 53, separated by weirs 56, 57; sand is heated in the first fluidised bed section 51 by electrical heating elements 55, held at a treatment temperature in the second bed section 52 without further input of heat, and cooled by cooling tubes 59 in the final fluidised bed section 53.

FIG 4



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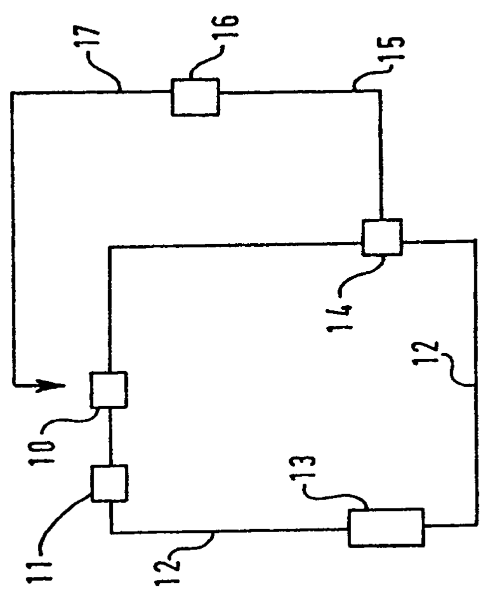


FIG 1

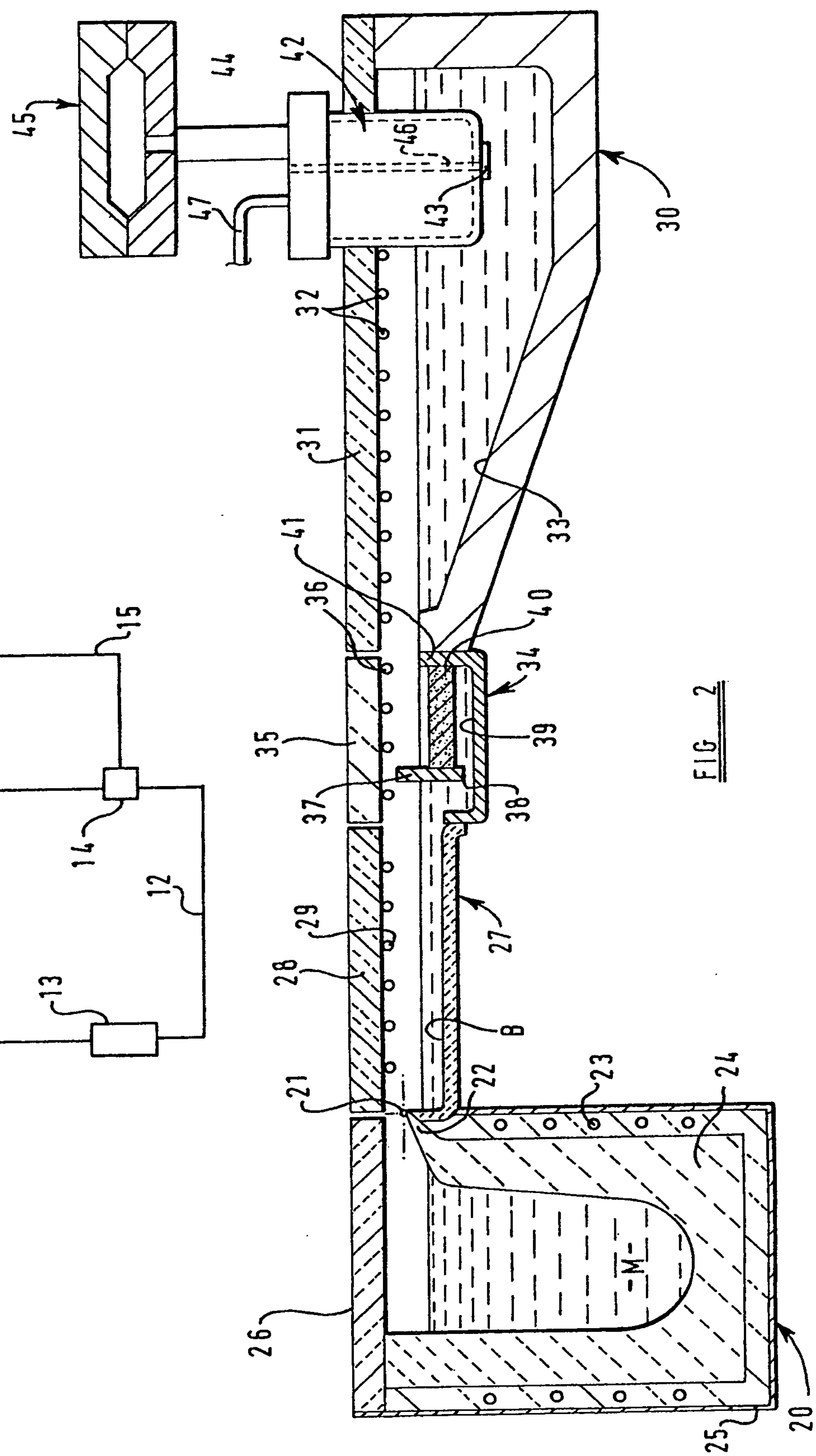


FIG 2

FIG 3

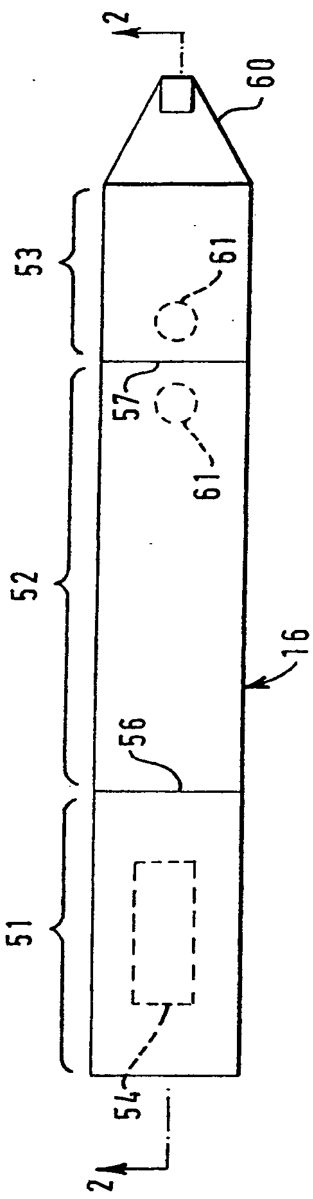
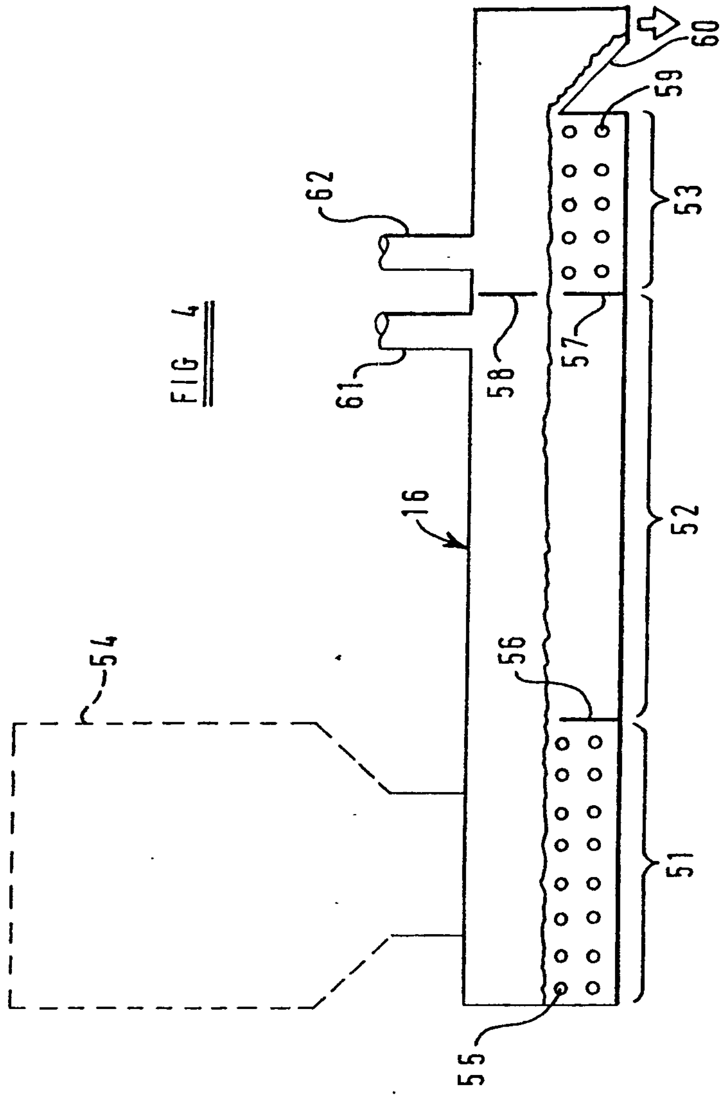
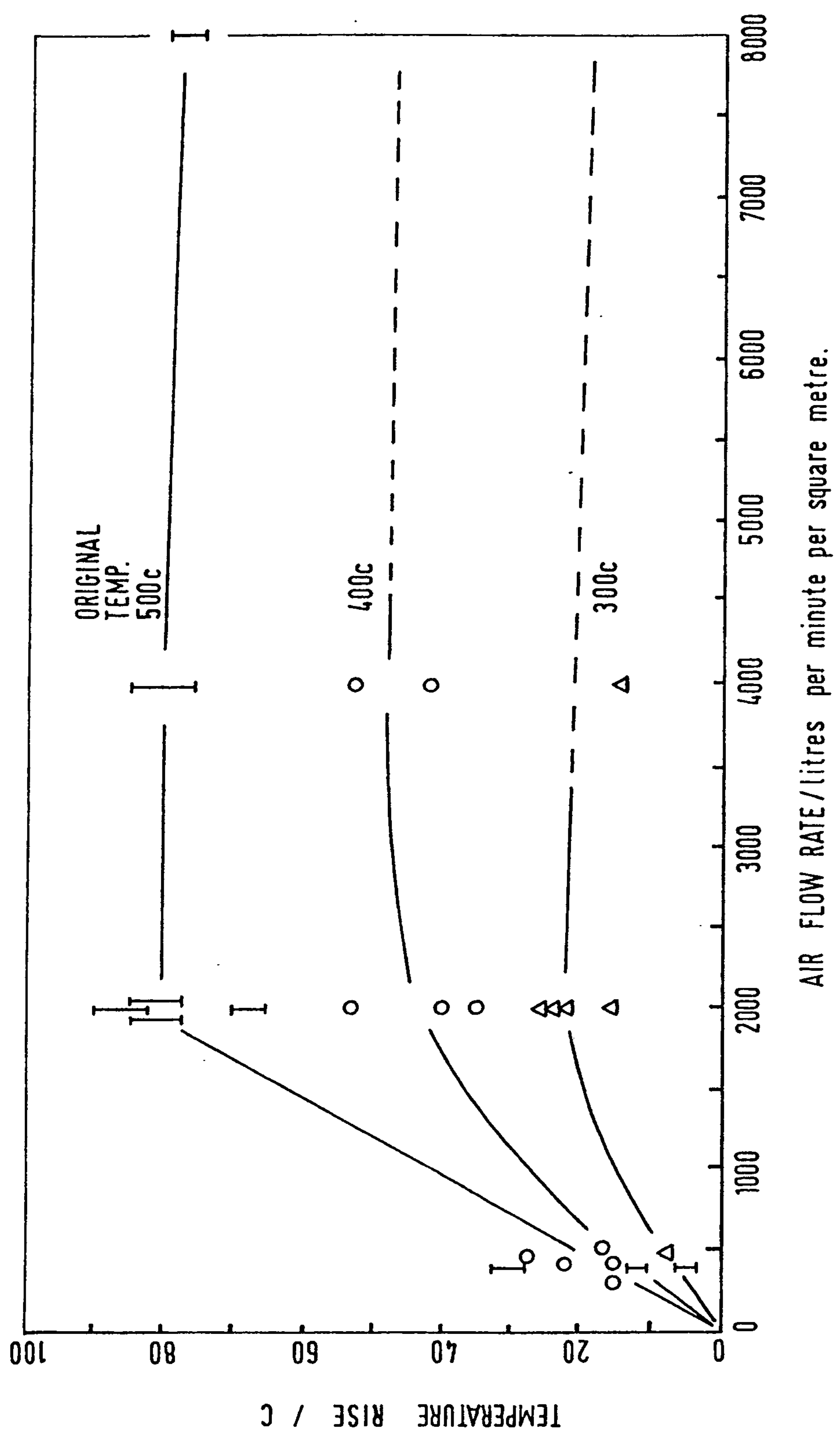


FIG 4





ORIGINAL TEMP. 500c
400c
300c
TEMPERATURE RISE / C
0
20
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80
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AIR FLOW RATE/litres per minute per square metre.
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6000
7000
8000

FIG 5

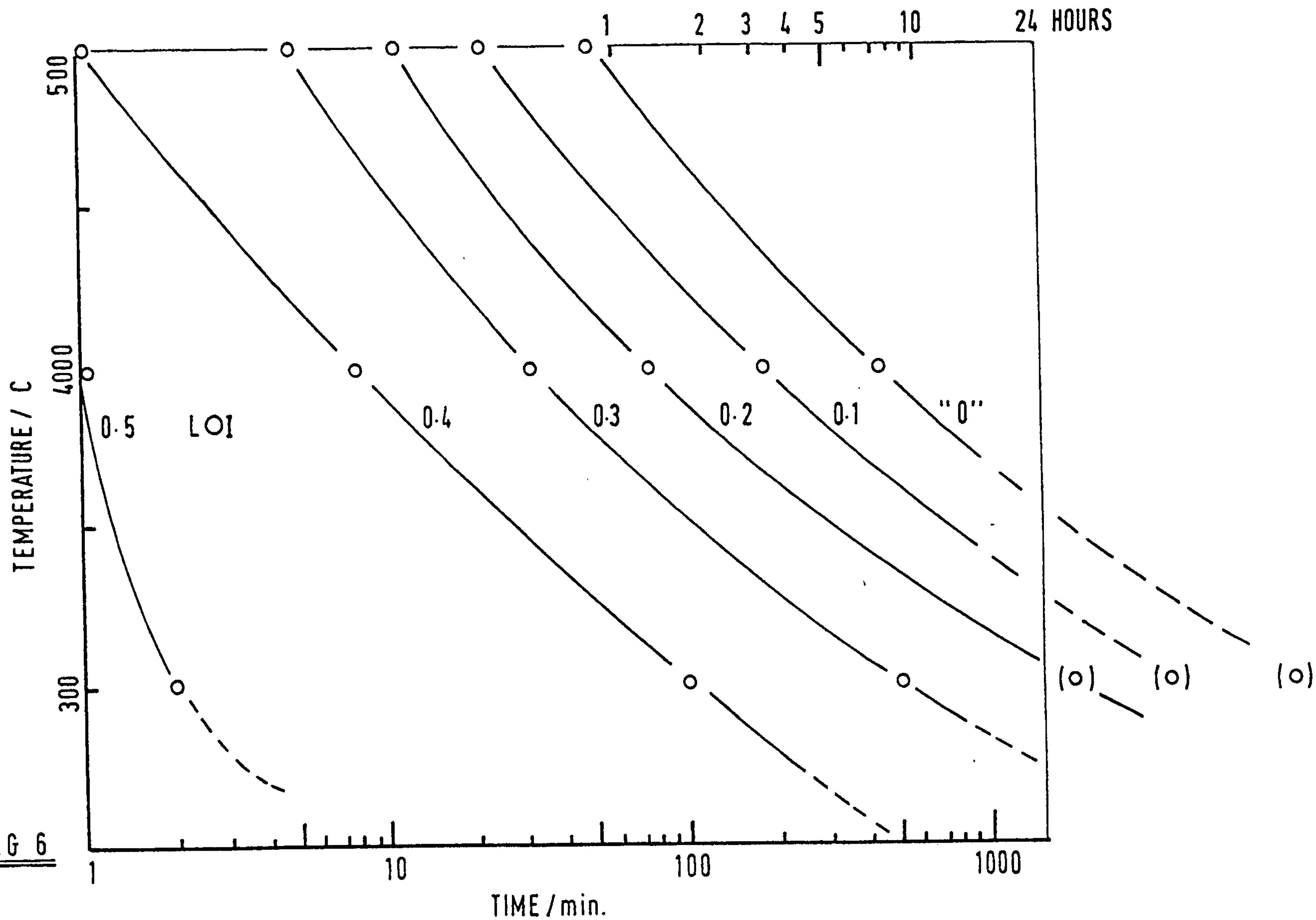
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FIG 6

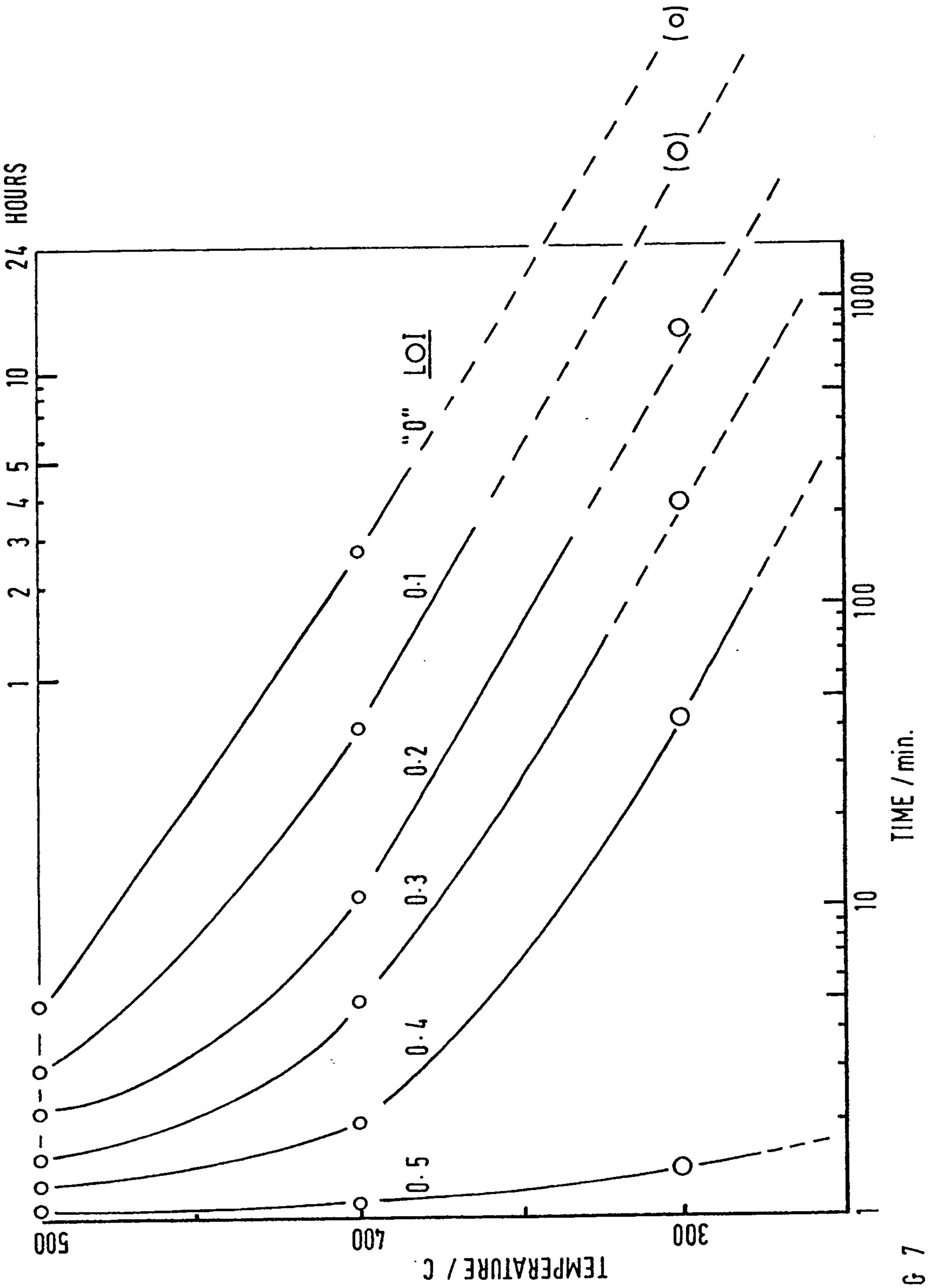
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FIG 7

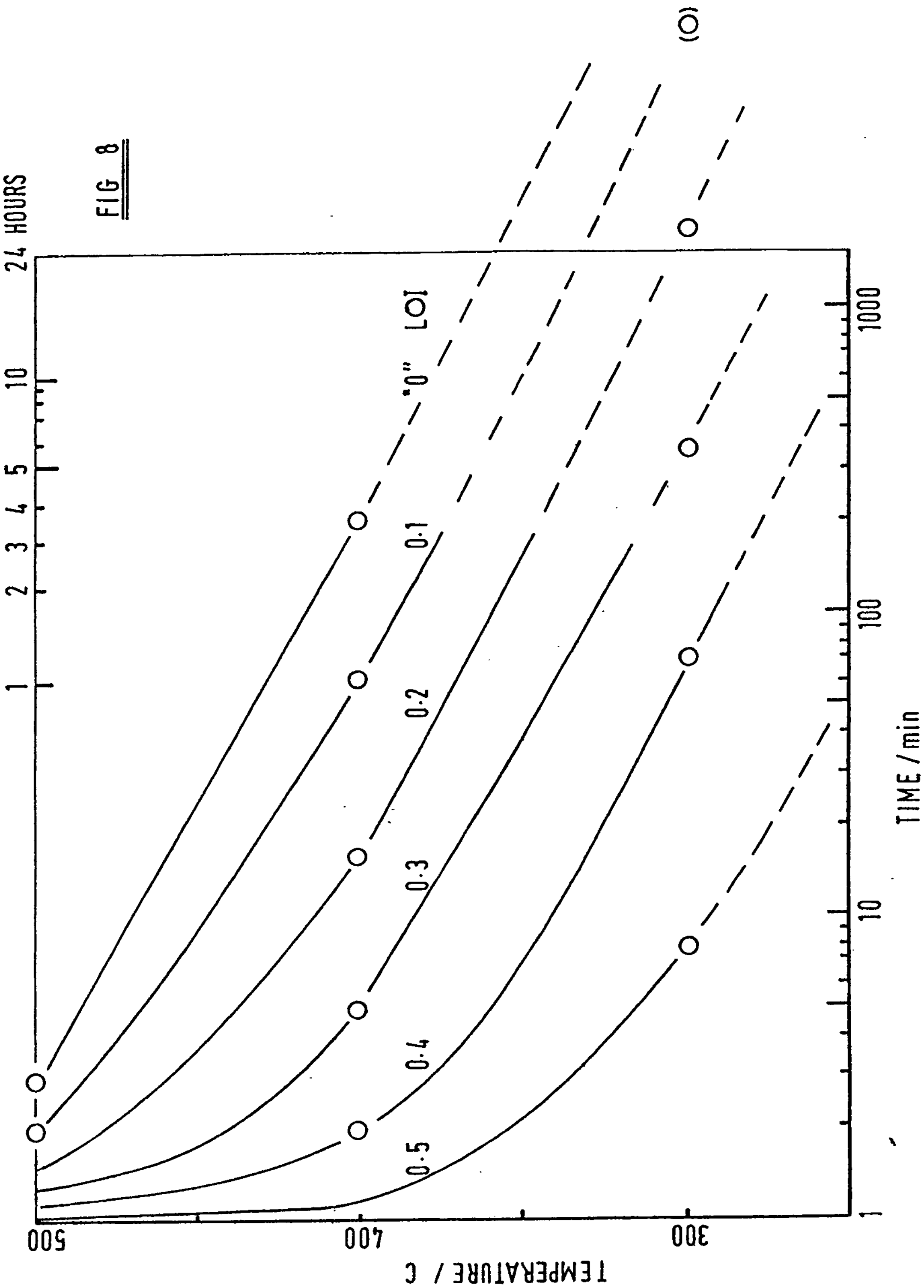
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FIG 8

SPECIFICATION

Casting Metal and Reclaiming Foundry Sand

This invention relates generally to casting metal using shape-defining parts such as moulds and/or cores made of organically bonded foundry sand and more particularly relates to a method of reclaiming the organically bonded foundry sand after it has been used for casting.

Conventionally, organically bonded foundry sand has been reclaimed by burning off the organic binder components using a fuel fired (gas or oil) heated system operating in the temperature range 800°C to 1000°C and in which the used sand is agitated during burning off of the organic binder components, for example in a rotary kiln.

In our prior specification GB 2,091,148A there is described a method of reclaiming used organically bound foundry sand in which the used sand is separated from castings and placed in a stationary container wherein the sand is maintained without agitation whilst combustion supporting gas is provided to the container and allowed to percolate through the sand by natural convection. The sand is held in a temperature range of 250°C to below 400°C for a time sufficient to reclaim the sand. Whilst this method avoids the need for plant capable of operating at high temperature and of agitating the sand, such as a rotary kiln, it suffers from the shortcoming that for certain applications the time taken for reclamation is inconveniently long and involves the storage of large quantities of sand in large containers as well as problems of conveying the sand and of control. The capital cost of the plant is, therefore, high and its efficiency relatively low.

From one aspect the present invention provides a method of reclaiming used foundry sand containing an organic binder comprising the steps of separating said sand from a casting, supplying said sand to a fluid bed, fluidising said sand in said fluid bed with combustion supporting gas introduced into said sand at a plurality of locations so that the sand remains in said fluid bed in a fluidised state at an elevated treatment temperature range to reclaim said sand and removing reclaimed sand from said fluid bed.

As a result we have found that satisfactory reclamation is achieved in a time measured in minutes as opposed to the time measured in hours as disclosed in GB 2,091,148A, the need for storage of large quantities of sand in large containers is avoided and conveying and control problems are also avoided.

Preferably, said sand is supplied to said fluid bed without fluidising said sand prior to entry into said fluid bed. Preferably, after separating said sand from said casting, said sand is not heated in the presence of combustion supporting gas prior to supplying said sand to said treatment station, and in particular said sand is not heated whilst being fluidised by combustion supporting gas. This is to avoid evolution of fumes prior to heating of the sand at the treatment station since the sand is brought to the treatment temperature range relatively quickly, e.g. in the order of ten secs. If the used sand is brought relatively slowly to the treatment temperature range in the presence of fluidising gas, then excessive fumes will be evolved.

Said sand may be supplied into said fluid bed in said treatment temperature range by virtue of being heated in a metal casting process in which said sand has been previously used, the metal casting temperature and the metal-to-sand ratio being such that the sand is heated so as to be in the treatment temperature range.

Alternatively the sand may be initially at or substantially at ambient temperature and said sand may be supplied into said fluid bed at or substantially at ambient temperature and heat is applied to said sand in said fluid bed to bring said sand to said treatment temperature range.

Further alternatively, said sand may be supplied into said fluid bed at a temperature between ambient temperature or substantially ambient temperature and said treatment temperature range by virtue of being heated in a metal casting process in which said sand has been previously used and further heat is applied to said sand in said fluid bed to bring said sand to said treatment temperature range.

Where the method involves heating said sand in said fluid bed, said sand may be introduced into a first fluid bed section wherein said sand is fluidised by said combustion supporting gas and heat is applied to said sand to heat said sand to said treatment temperature range and wherein said sand is partially reclaimed and the partially reclaimed sand passes into a further fluid bed section wherein said sand is fluidised by said combustion supporting gas at a temperature in said treatment temperature range to continue reclamation of the sand.

The sand may remain in the further fluid bed section without the application of heat or with the application of heat but a lesser amount of heat than is applied in the first fluid bed section.

Said fluid bed or fluid bed section may be heated by means which avoid combustion of fuel within said sand so that said combustion supporting gas is available for combustion of the binder.

Said sand may be heated by a plurality of heating elements immersed in the sand, the heating elements may be electrical heating elements immersed in the sand, or a combustion chamber and/or smoke tubes of a furnace in which fuel is burned.

After treatment of the sand in the first fluid bed section or the first and second fluid bed sections where two fluid bed sections are provided, the sand may be passed to a cooling fluid bed section wherein said sand is fluidised and cooled to a desired temperature;

After separating said sand from said casting, said sand may be reduced to grain size or substantially to grain size.

Said sand may be selected from the group

consisting of silica, zircon, olivine or chromite sand.

The binder may be selected from the group consisting of a chemically hardened resin binder or a thermo-setting resin or a "hot box" resin and may be selected from the group consisting of phenolic, furane, isocyanate or acrylic resin binder.

The treatment temperature may lie in the range 250°C to 600°C, and preferably lies in the range 300°C to below 400°C and more preferably lies in the range 400°C to 500°C, and still more preferably lies in the range 450°C to 500°C.

According to another aspect of the invention, we provide a method of making a metal casting comprising the steps of making a mould using reclaimed used foundry sand and an organic binder, hardening the mould, casting molten metal into the mould to make a casting, separating said sand from the casting, reclaiming said sand by a method according to the first aspect of the invention and then using the thus reclaimed sand in a repetition of the method.

The metal may be a non-ferrous metal selected from the group consisting of aluminium, magnesium, copper and alloys based on said metals and said reclaimed sand of which the mould is made may be predominently reclaimed used zircon sand.

The mould may comprise in addition to a catalyst or hardening agent for the resin binder;

50% to 100% zircon sand, by total weight of sand;

0.4% to 1% resin binder, by total weight of sand;

0% to 50% sand or sands other than zircon sand, by total weight of sand.

Said sand of which the mould is made may comprise wholly or substantially wholly zircon sand.

The metal may be melted in a melting vessel, transferred from the melting vessel to a casting vessel and transferred upwardly from the casting vessel into the mould.

The metal may be transferred from the melting vessel into the casting vessel by flow of metal under gravity and the level of the top surface of the metal as the metal leaves the melting vessel may be above the top surface of the metal in the casting vessel by not more than a maximum distance above which excessive turbulence occurs; this maximum distance may lie within the range 50 mm to 200 mm.

The use of zircon sand as a foundry moulding material is well known in the production of iron and steel castings. Zircon sand is used mainly because of its high refractoriness, i.e. it does not fracture nor melt under conditions of thermal shock when casting ferrous materials. Usually such moulds are produced by the Croning (Shell) process, which uses phenolic based thermo-setting resins. Although the process has a reasonable reputation for the accuracy of the resulting castings, the accuracy is necessarily limited by the use of hot metal patterns, which are subject to thermal distortion and the distortion of the thin shell moulds.

In ferrous foundries using the Shell Process, the expensive zircon sand is re-claimed by a number of existing thermal reclamation systems, most of which heat the sand to a temperature in the range 800°C to 1,000°C to burn off the remaining resin prior to re-coating with fresh resin. The high cost of such reclamation is usually recoverable in the relatively high price of such ferrous shell-moulded castings.

Because aluminium, magnesium, copper and other metals having a melting point below that of ferrous metals and alloys based thereon do not require the refractoriness of zircon sand, moulds for these metals have traditionally been made only in silica or other cheaper sands. Only occasionally have cores been made in zircon sand.

The use of zircon sand and its reclamation in accordance with the present invention provides a metal casting process having a number of extremely important and unexpected benefits as follows.

The accuracy of cored holes and wall thicknesses defined by cores, are improved by a factor of up to twenty times. External features of castings are typically five times more accurate than their silica sand cast counterparts. This improvement in accuracy follows from the low expansion combined with the high thermal capacity of zircon sand compared to silica. It enables the accuracy to exceed the accuracy of all other casting methods known to date including investment and pressure die casting. The high thermal capacity increases freezing rate and also improves mechanical properties.

Sand expansion defects, such as scabs, rat-tails, finning, flash and the like are eliminated.

The levels of addition of the resin binder are significantly lower than those used for the Croning Shell Process. Because the patterns are used at or near to room temperature, they retain their accuracy and so produce accurate moulds and cores. Also, the moulds can be made of any convenient thickness as a thick shell, or in the form of block moulds, or can be made in steel boxes or frames. In this way, also, accuracy can be conserved (compared and contrasted with a thin Croning Shell mould which is easily distorted).

According to a third aspect of the invention we provide a casting made using the method according to the second aspect of the invention.

According to a further aspect of the invention, we provide an apparatus for reclaiming used foundry sand containing an organic binder comprising means for separating a mass of said sand from a casting, sand supply means to supply the separated sand to a fluidised bed, fluidising means to introduce combustion supporting gas into said sand at a plurality of locations in said fluid bed to fluidise the bed, means to maintain said sand in said fluid bed in an elevated treatment temperature range to reclaim said sand

and means for removing the reclaimed sand from the fluid bed.

Preferably said sand supply means supplies said sand to said fluid bed without fluidising said sand prior to entry of said sand into said fluidised bed. Said sand supply means may supply said sand to said fluid bed without heating said sand.

More generally, said sand supply means may restrict contact between the sand and combustion supporting gas prior to introduction of the sand into the fluid bed.

Said fluid bed may have heating means to heat said sand to said treatment temperature range.

Said fluid bed may comprise a first fluid bed section into which said sand supply means supplies said sand, in use, and having fluidising means to introduce combustion supporting gas into said sand at a plurality of locations to fluidise the bed and a heating means to heat the bed to said treatment temperature range to partially reclaim said sand and sand passage means to pass partially reclaimed heated sand from the first fluid bed section to a further fluid bed section having fluidising means to introduce combustion supporting gas into the sand in the further fluid bed section at a plurality of locations to fluidise the bed and means to maintain the bed in the further fluid bed section in said treatment temperature range whereby reclamation of the sand is continued.

Means may be provided whereby said sand remains in said further fluid bed section in said treatment temperature range without application of heat so as to continue reclamation utilising heat in said sand from the first fluid bed section.

Alternatively, said further fluid bed section may be provided with heating means whereby said sand is maintained in said further fluid bed section in said treatment temperature range so as to continue reclamation partly by utilising heat in said sand from said first fluid bed section and with application of a lesser amount of heat than is applied in said first fluid bed section.

Where the fluid bed or a fluid bed section has heating means, the heating means may comprise a plurality of heating elements immersible in the sand.

The heating elements may comprise electrical heating elements which may be electrical conductors in direct contact with the sand and through which electrical heating current at low voltage is passed, in use.

Alternatively, the heating elements may comprise a combustion chamber and/or smoke tubes of a furnace in which fuel is burned, in use.

The fluidising means may comprise a plurality of discrete openings through which said combustion supporting gas is directed to the sand, said openings being provided with shield means to shield the openings from ingress of sand.

Means may be provided to reduce the sand to grain size or substantially to grain size after separating said sand from said casting.

The invention will be described in more detail by way of example with reference to the accompanying drawings wherein:—

Figure 1 is a schematic illustration of a light alloy foundry casting plant for carrying out a method embodying the invention;

Figure 2 is a diagrammatic cross-sectional view of the melting and casting apparatus of the plant of Figure 1;

Figure 3 is a diagrammatic plan view of a sand reclamation apparatus of the plant of Figure 1;

Figure 4 is a section on the line 4—4 of Figure 3;

Figure 5 is a graph showing rise in temperature of sand during reclamation as a function of the sand's original temperature and air flow rate;

Figure 6 is a set of Time Temperature Transformation (TTT) curves for different extents of reclamation expressed as residual binder content as measured by loss on ignition (LoI) at an air flow rate of 400 l/min/m^2;

Figure 7 is a similar set of TTT curves but for an air flow rate of 2000 l/min/m^2; and

Figure 8 is a similar set of TTT curves but for an air flow rate of 4000 l/min/m^2.

Referring now to Figure 1, a foundry plant suitable for casting aluminium, magnesium, copper and alloys based on said metals or the like comprises a moulding station 10 where moulds are made of organically bonded foundry sand, in the present example zircon sand, but which may be made of other sands such as silica sand, olivine sand, chromate sand or a mixture of such sands. The sand is bonded with an organic binder such as a chemically hardened resin, such as a gas hardened resin, for example furane resin with methyl ethyl ketone peroxide (MEKP) hardened with SO_2 or isocyanate resin, hardened with amine gas or acrylic resin with MEKP hardened with SO_2, or a liquid catalyst hardened resin, for example furane resin hardened with sulphonic acid, or a thermosetting resin for example a thermosetting phenolic resin or "hot box" resin, or with any binder which can be reclaimed by heating in the presence of a combustion supporting gas to produce gaseous products of combustion/oxidation.

The mould may be made by ramming but, in the present example, are blown using an automatic mould blowing machine. The mould may be used in conventional mould boxes or a boxless process, as in the present example may be used. In the present example, the mould comprises 98% zirconium silicate sand; 0.55% furane resin, by weight of sand; 0.20% methyl ethyl ketone peroxide, by weight of sand; 2% usual impurities such as oxides of transition elements and bound with furane resin. The resin was hardened using S02 gas amounting to about 0.25% S02 equivalent by weight of sand. The sand has an average grain size of 145 mm.

If desired, the mould may comprise 50% to 100% zircon sand, by total weight of sand; 0.4% to 1% resin binder, by total weight of sand; 0% to 50% sand or sands other than zircon sand, by total weight of sand. Preferably however, the

sand comprises wholly or substantially wholly zircon sand.

The zircon sand may have an average particle grain size lying in the range 50 to 500 mm.

A core or cores similarly made of organic resin bonded sand either the same sand and binder system as the remainder of the mould or otherwise, is positioned, as necessary, within the mould cavity at a mould assembly station 11 where the cope and drag halves of the mould are closed.

These moulds are transferred by a conveyor 12 to a casting station 13 where molten metal, in the present example magnesium alloy, is cast through ingates into the mould cavity and around the core or cores when present. Details of the melting of the metal and casting are described below with reference to Figure 2. After casting, the filled mould is transferred by a conveyor 12 to a shakeout station 14 where the sand of the mould and core or cores, when present, is shaken out of the casting and the used sand is fed by a conveyor 15 to a sand reclaiming plant 16 to be described hereinafter in more detail with reference to Figures 3 to 8, where the sand is reclaimed and the thus reclaimed sand is then supplied by a conveyor 17 to the moulding station 10 where binder is mixed with the reclaimed sand and new cope and drag parts of the mould made and transferred to the mould assembly station 11.

In the present example, the metal, which is a magnesium alloy, is melted in a melting vessel 20 comprising a conventional lip action tilting type furnace mounted for tilting movement about a horizontal axis 21 coincident with a pouring lip 22. The furnace is electrically heated by means of an induction coil 23 and has a refractory lining 24 within an outer steel case 25 and an insulated lid 26. A ceramic launder 27, provided with an insulated lid 28 having electric radiant heating elements 29, extends from the lip 22 to a casting vessel 30. The casting vessel 30 comprises a holding furnace having a lid 31 with further electric radiant heating elements 32 therein and has a relatively large capacity, in the present example one ton.

The casting vessel is of generally rectangular configuration in plan view but has a sloping half 33 (to maximise its area/volume) extending towards the launder 27.

Interposed between the launder 27 and the filling spout 33 is a filter box 34 provided with a lid 35 having electric radiant heat elements 36. A weir 37 extends between side walls of the filter box 34 and has a bottom end 38 spaced above the bottom 39 of the filter box. A replaceable filter element 40 is positioned between the weir 37 and the downstream end wall 41 of the filter box and is made of a suitable porous refractory material.

A pump 42 is positioned in relation to the casting vessel 30 so that an inlet 43 of the pump will be immersed in molten metal within the casting vessel and has a riser tube 44 which extends to a casting station so as to permit uphill filling of a mould 45 thereat. The pump 42 has a stopper rod 46 to close the inlet 43 and an inert gas supply conduit 47. When it is desired to pump metal from the casting vessel 30 into the mould 45, the stopper rod is moved downwardly to close the inlet 43 and inert gas under pressure is supplied through the conduit 47 to force metal within the pump body upwardly through the riser tube 44 into the mould 45. The gas pressure is maintained at an appropriate level to ensure satisfactory filling of the mould sufficiently long to ensure that the casting formed in the mould cavity is solidified but not so long as to cause solidification to extend down ingates. The gas pressure is then released by venting the gas to atmospheric pressure and lifting the stopper rod 46 to open the inlet 43 thereby allowing the metal within the pump 42 to attain the same level as the metal in the casting vessel 30.

The axis 21 about which the melting furnace is tilted is positioned so that, in the present example, the top surface of the metal as it leaves the melting vessel is 100 mm above the minimum height to which it is intended that the level of metal in the casting vessel 30 and hence in the launder 27 should fall, so that the distance through which the metal falls freely is limited to 100 mm. Whilst a height of 100 mm is the distance in the present example, if desired the distance may be such that during the pouring the level of the top surface of the metal leaving the furnace is at a maximum distance of 200 mm above the above mentioned minimum level. The above described melting, transferring casting procedure provides a method which is capable of high and continuous production capacity in which turbulence and its effects are substantially eliminated and from which high quality castings are consistently produced, this is because free fall of metal through the atmosphere is minimised and pumping is performed in a quiescent manner.

Referring now to Figures 3 and 4, there is illustrated the reclaiming apparatus 16 in which sand is reclaimed by being maintained in a treatment temperature range in the presence of a combustion supporting gas.

The apparatus 10 comprises a series of connected fluid bed sections 51, 52 and 53 and a hopper 54 to which sand to be reclaimed is fed.

The sand in the present example is fed from a shake or knock-out station 14 of the magnesium alloy foundry casting plant at such a rate that the sand is only slightly above ambient temperature. Alternatively the sand may be fed in such a way, or stored in the hopper 54 for such a period, that it is at ambient temperature on leaving the hopper 54.

However, the sand may be delivered, for example, from a ferrous casting plant knock-out at such a rate and temperature and the reclaiming apparatus 16 operated at such a rate that the sand leaving the hopper 54 is at a temperature in the treatment temperature range. Alternatively, operating conditions may be such that the sand is at a temperature lying between ambient or

substantially ambient temperature and the treatment temperature range. The sand is reduced to grain size or substantially to grain size by the shake-out or if necessary by an attrition unit, crushing unit or other means.

Sand to be reclaimed is fed from the hopper 54 to the first fluid bed section 51 by means of a screw conveyor, air slide or other convenient controlling device. The sand advantageously may be fed into the fluid bed section 51 below the surface of the bed by for example a screw conveyor.

The fluid bed section 51 contains a high density of electrical heaters 55 which heat the sand to a temperature lying in the treatment temperature range. The heaters 55 are preferably low voltage heaters operating at about 40—50 volts and comprising stainless steel strips through which low voltage electric heating current is passed in direct contact with the sand. The heaters 55 heat the sand as rapidly as possible so as to reduce smoke or other fume emission and to gain as much energy from the burning resin as possible. Sand is raised from slightly above ambient temperature to the treatment temperature range very rapidly in a matter of a few seconds at most in the present example.

Application of heat to the sand in the presence of combustion supporting gas prior to heating in the fluid bed section 51 is avoided and especially avoided are any steps involving feeding fluidising gas into contact with the sand prior to the sand entering the fluid bed section 51. For example there is no fluidisation of the sand at elevated temperature prior to entry of the sand into the fluid bed section 51 thereby minimising evolution of smoke and other fumes from the sand.

Of course, when the sand is already at a temperature in the treatment temperature range, no such heaters 55 are required and when the sand is substantially above ambient temperature, but below the treatment temperature range, a lower density of heaters in the fluid bed 51 may be provided. In such cases, it is preferred to take steps to minimise the time the sand remains at said elevated temperature prior to entering the fluid bed section 51 and to minimise contact of the hot sand with any high velocity gas which will drive out smoke and other noxious pollutants from the hot sand.

The first fluid bed section 51 is separated from the further fluid bed section 52 by means of a weir 56 and sand passes from the first to the second section over the top of the weir. In the further fluid bed section 52 sand is allowed to dwell in the treatment temperature range without further input of heat, thus allowing combustion of the organic binder to proceed in the fluidising air by utilising the heat in the sand from the first fluid bed section. As to be discussed in more detail hereinafter, the cooling of the sand from the fluidising air is measurable but not important in this section of the apparatus. If in any particular application supplementary heating is required in this section, the requisite number of heating elements may be provided to make up losses as necessary. If desired, a further fluid bed section or sections may be provided at which the sand is maintained in said treatment temperature range. The first and the or each further fluid bed section are thermally insulated to prevent heat loss therefrom except that heat can transfer between the first and further fluid bed sections via the weir 56.

The third fluidised bed section 53 is thermally insulated from the previous sections by means of an insulating weir 57 and a baffle 58 and contains cooling tubes 59 which are conveniently cooled by water but may be cooled by other liquid or gas. The sand is cooled in this section to the desired temperature. For example, with an SO_2/furane resin binder system the sand is cooled to a temperature in the range 30—35°C which is an optimum temperature for reuse with this sort of binder system.

In the present example, reclamation of the sand by combustion of the binder is completed to the required standard in the further fluid bed section. However, the method may be operated so that the reclamation is not so completed in the further fluid bed section and reclamation is completed to the required standard in the cooling fluid bed section before the temperature of the sand is reduced to below the treatment temperature range in which reclamation occurs. In all cases however, reclamation is completed to the required standard whilst the sand is fluidised. In the present example, the sand is reclaimed to the extent that the residual binder content as measured by "Loss on Ignition" lies in the range 0.05 to 0.10% but the process may be operated with more or less reclamation so long as adequate reclamation for re-use of the sand is achieved and the term "reclaimed" is used herein to refer to such an extent of reclamation. Typically, the minimum extent of reclamation for re-use is a residual binder content of 0.2% but we do not want to be limited to this since, for example, some people using furane resin binder accept a higher residual binder content whilst other people using phenolic resin binder insist on a lower residual binder content than 0.05%.

Other binder systems require the sand to be cooled to other optimum temperatures. For example, for the recoating of phenolic resins on shell sands the temperatures may lie in the range 120—150°C at the discharge from the cooling or third section 53. In this latter case air cooling in at least some of the cooling tubes may be desirable or the water cooling section reduced in size for the number or water cooling tubes reduced.

The sand exits from the third fluidised bed section 53 via a discharge tube 60.

Although in the present example the three fluid bed sections are separated by weirs, if desired they may be separated by other means such as separating plates having one or more openings therein or may be completely independent bed sections connected by ducts. Alternatively, the

sections may not be separated by any physical barrier; each section being functionally defined. For example the first section may comprise a part of a single fluid bed having a high density of heater elements, the second section by a part of the fluid bed having no or a lower density of heating elements than in the first section and a cooling section, when provided, by a part of the bed which may have cooling elements.

Hot dusty gas is exhausted via ducts 61, 62 and is passed through a dust extraction system, not shown, prior to exhausting to atmosphere.

Fluidising gas, in the present example air, is provided to all three sections through a plurality of discrete openings which are provided with shield means to shield the openings from ingress of sand. The openings may be provided for example in a plurality of tubes immersed in the sand and to which fluidising gas is fed. The fluidising gas may be provided by means of sparge tubes or by means of a porous bottom to the sections for example a gas permeable material, a foraminous plate or mesh. It is preferred however to introduce the gas through discrete openings since this avoids problems which can arise using porous material, a foraminous plate or mesh since these can suffer from blockage of an area of the porous material, plate or mesh causing the bed to become non-fluidised above these regions leading to localised overheating.

The above described apparatus is used to carry out a method of reclaiming used foundry sand which comprises, in the present example, feeding sand to be reclaimed into the hopper 54 and then from the hopper 54 into the first fluidised bed section 51.

The sand to be reclaimed is heated in the first fluidised bed section 51 to a treatment temperature range in which reclamation occurs. This range may be 450°C to 600°C. However, if desired the temperature may be anywhere in the range 250°C to 500°C, preferably in the range 300°C to below 400°C and more preferably in the range 400°C to 500°C. The sand in the second fluid bed section 52 may be at the same temperature as in the first fluid bed section or at a lower temperature but still within the above mentioned treatment temperature range.

Since, in the present example, the temperature of the sand does not exceed 600°C the apparatus described with reference to Figures 1 and 2 may be made, for example, of mold steel as it does not have to withstand high temperatures. Of course, the electrical heaters are required to be made of a suitable high temperature material since these run at temperatures of up to 800°C. The electrical heaters may comprise instead of the above described low voltage heaters, conventional electric heaters operating at high voltage alternating current, i.e. a heating element within a tube so as to be electrically insulated from the sand. Electrical heating of the bed is useful to achieve simple control and to ensure that all the available oxygen in the air is available for burning the organic binder (and not the added fuel as is the case for a fuel fired bed).

If desired other means of heating the bed may be used which avoid combustion of the fuel within the bed. For example gas or oil or other fuel may be combusted in a combustion chamber and the products of combustion passed through smoke tubes immersed in the fluidised bed. If desired the combustion chamber may be immersed in the fluidised bed and may be with or without smoke tubes.

Experiments have been carried out to determine the range of temperature and air flow rates over which the method embodying the invention may be performed.

It has been found that if air is used as the combustion supporting gas and is forced through the sand to be reclaimed at a rate of at least 400 litres/min/metres^2 (l/min/m^2) and preferably equal to, or in excess of, 2000 l/min/m^2, then an adequate level of reclamation is achieved in a time scale measured in minutes. For example, approximately 10 minutes at 400°C and three minutes at 500°C for furane polymer resin containing (Methyl Ethyl Ketone Peroxide (MEKP) and hardened with sulphur dioxide gas.

Additionally, at a flow rate in the range approximately 2000—2400 l/min/m^2 is found that most foundry sands start to fluidise and satisfactory fluidisation is generally achieved over the range 2500—8000 l/min/m^2. Fluidisation can occur at lower flow rates depending on the grain size of the sand. Thus the apparatus used is simple, efficient and compact being in the form of a series of fluid beds through which the sand flows automatically without requiring any conveyor means.

At a flow rate above about 3000 l/min/m^2 cooling by the excess air starts to be noticeable although does not become significantly deleterious until the flow rate exceeds about 8000 l/min/m^2.

Referring now to Figure 5, there are shown three curves for reclaiming used sand at an original temperature of 500°C, 400°C and 300°C respectively. The temperature rise in the sand to be reclaimed, as a result of the exothermic reclaiming reaction, is plotted against the air flow rate in litres per minute per square metre. The curves indicate that for all three original temperatures an optimum performance is achieved in the region of 2000—3000 l/min/m^2.

Referring now to Figures 6 to 8, there is shown the rates of reclamation from sand having an original organic binder content of 0.75% as measured by loss on ignition (LoI) for air flow rates 400, 2000 and 4000 l/min/m^2 respectively.

Referring now to Figure 6, this shows the rates of reclamation at a below optimum flow rate of air of only 400 l/min/m^2. The time temperature transformation (TTT) curve for a residual organic binder content of 0.2% (measured by LoI) indicates a useful working level at which reclamation is adequate for many processes, i.e. the sand is satisfactory for reuse. At this flow rate

a time of 60 minutes is necessary to adequately reclaim sand at 400°C. At the optimum rate of air flow (2000 l/min/m^2 shown in Figure 5 the time required is thirteen minutes. This time lengthens to eighteen minutes as cooling becomes noticeable at 4000 l/min/m^2 as shown in Figure 8.

At 300°C the times for the same residual binder content, i.e. 0.2% (LoI) are thirty-three, thirteen and thirty-three hours respectively as can be seen from Figures 6, 7 and 8.

In practice the temperature and flow rate for the practical application of our method are chosen on the basis of TTT curves to achieve optimum operating conditions for the application concerned.

If desired the sand may be reclaimed at a treatment station 16 comprising a single fluid bed at which the sand is fluidised at a temperature in the treatment temperature range and heating elements may be provided at only the entry end of the bed or throughout the length of the bed at a uniform distribution or a non-uniform distribution so as to cause the temperature in the bed to decrease towards the exit end thereof. If desired, in any particular application the sand may be fed from the treatment station at elevated temperature without passing through a cooling fluidised bed section.

Compositions herein are expressed in % by weight.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, or a class or group of substances or compositions, as appropriate, may, separately or any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A method of reclaiming used foundry sand containing an organic binder comprising the steps of separating said sand from a casting, supplying said sand to a fluid bed, fluidising said sand in said fluid bed with combustion supporting gas introduced into said sand at a plurality of locations so that the sand remains in said fluid bed in a fluidised state at an elevated treatment temperature range to reclaim said sand and removing reclaimed sand from said fluid bed.

2. A method according to Claim 1 wherein said sand is supplied to said fluid bed without fluidising said sand prior to entry into said fluid bed.

3. A method according to Claim 1 or Claim 2 wherein after separating said sand from said casting, said sand is not heated prior to supplying said sand to said fluid bed.

4. A method according to any one of the preceding claims wherein said sand is supplied into said fluid bed in said treatment temperature range by virtue of being heated in a metal casting process in which said sand has been previously used.

5. A method according to any one of the preceding claims wherein said sand is supplied into said fluid bed at or substantially at ambient temperature and heat is applied to said sand in said fluid bed to bring said sand to said treatment temperature range.

6. A method according to any one of Claims 1 to 4 wherein said sand is supplied into said fluid bed at a temperature between ambient temperature or substantially ambient temperature and said treatment temperature range by virtue of being heated in a metal casting process in which said sand has been previously used and further heat is applied to said sand in said fluid bed to bring said sand to said treatment temperature range.

7. A method according to Claim 5 or Claim 6 wherein said sand is introduced into a first fluid bed section wherein said sand is fluidised by said combustion supporting gas and heat is applied to said sand to heat said sand to said treatment temperature range and wherein said sand is partially reclaimed and the partially reclaimed sand passes into a further fluid bed section wherein said sand is fluidised by said combustion supporting gas at a temperature in said treatment temperature range to continue reclamation of the sand.

8. A method according to Claim 7 wherein said sand remains in said further fluid bed section without application of heat so as to continue reclamation utilising heat in said sand from said first fluid bed section.

9. A method according to Claim 7 wherein said sand remains in said further fluid bed section so as to continue reclamation partly utilising heat in said sand from said first fluid bed section and with application of a lesser amount of heat than is applied in said first fluid bed section.

10. A method according to any one of Claims 5 to 9 wherein said fluid bed or fluid bed section is heated by means which avoid combustion of fuel within said sand so that said combustion supporting gas is available for combustion of the binder.

11. A method according to Claim 10 wherein said sand is heated by a plurality of heating elements immersed in the sand.

12. A method according to Claim 11 wherein said sand is electrically heated by electrical heating elements immersed in the sand.

13. A method according to Claim 10 wh rein said sand is heated by immersion in the sand of a combustion chamber and/or smoke tubes of a furnace in which fuel is burned.

14. A method according to any one of the preceding claims wherein said sand is introduced into a cooling fluid bed section wherein said sand is fluidised and cooled to a desired temperature.

15. A method according to any one of the preceding claims wherein after separating said sand from said casting, the sand is reduced to grain size or substantially to grain size.

16. A method according to any one of the preceding claims wherein said sand is selected from the group consisting of silica, zircon, olivine or chromate sand.

17. A method according to any one of the preceding claims wherein the binder is selected from the group consisting of a chemically hardened resin binder or a thermo-setting resin or a "hot box" resin.

18. A method according to Claim 17 wherein the binder is selected from the group consisting of phenolic, furane, isocyanate or acrylic resin binder.

19. A method according to any one of the preceding claims wherein the treatment temperature range is 250°C to 600°C.

20. A method of reclaiming used foundry sand substantially as hereinbefore described with reference to the accompanying drawings.

21. A method of making a metal casting comprising the steps of making a mould using reclaimed used foundry sand and an organic binder, hardening the mould, casting molten metal into the mould to make a casting, separating said sand from the casting, reclaiming said sand by a method as claimed in any one of the preceding claims and then using the thus treated sand in a repetition of the method.

22. A method according to Claim 21 wherein the metal is a non-ferrous metal selected from the group consisting of aluminium, magnesium, copper and alloys based on said metals and said reclaimed sand of which the mould is made is predominently reclaimed used zircon sand.

23. A method according to Claim 22 wherein the mould comprises, in addition to a catalyst or hardening agent for the resin binder;

50% to 100% zircon sand, by total weight of sand;

0.4% to 1% resin binder, by total weight of sand;

0% to 50% sand or sands other than zircon sand, by total weight of sand.

24. A method according to Claim 22 or Claim 23 wherein said sand comprises wholly or substantially wholly zircon sand.

25. A method according to any one of Claims 21 to 24 wherein the metal is melted in a melting vessel, transferred from the melting vessel to a casting vessel and transferred upwardly from the casting vessel into the mould.

26. A method according to Claim 25 wherein the metal is transferred from the melting vessel into the casting vessel by flow of metal under gravity and the level of the top surface of the metal as the metal leaves the melting vessel is above the top surface of the metal in the casting vessel by not more than a maximum distance above which excessive turbulence occurs.

27. A method according to Claim 26 wherein said maximum distance lies within the range 50 to 200 mm.

28. A method of making a metal casting substantially as hereinbefore described with reference to the accompanying drawings.

29. An apparatus for reclaiming used foundry sand containing an organic binder comprising means for separating a mass of said sand from a casting, sand supply means to supply the separated sand to a fluidised bed, fluidising means to introduce combustion supporting gas into said sand at a plurality of locations in said fluid bed to fluidise the bed, means to maintain said sand in said fluid bed in an elevated treatment temperature range to reclaim said sand and means for removing the reclaimed sand from the fluid bed.

30. An apparatus according to Claim 29 wherein said sand supply means supplies said sand to said fluid bed without fluidising said sand prior to entry of said sand into said fluidised bed.

31. An apparatus according to Claim 30 wherein the sand supply means supplies said sand to said fluid bed without heating said sand.

32. An apparatus according to any one of Claims 29 to 31 wherein said fluid bed has heating means to heat said sand to said treatment temperature range.

33. An apparatus according to any one of Claims 29 to 32 wherein said fluid bed comprises a first fluid bed section into which said sand supply means supplies said sand, in use, and having fluidising means to introduce combustion supporting gas into said sand at a plurality of locations to fluidise the bed and a heating means to heat the bed to said treatment temperature range to partially reclaim said sand and sand passage means to pass partially reclaimed heated sand from the first fluid bed section to a further fluid bed section having fluidising means to introduce combustion supporting gas into the sand in the further fluid bed section at a plurality of locations to fluidise the bed and means to maintain the bed in the further fluid bed section in said treatment temperature range whereby reclamation of the sand is continued.

34. An apparatus according to Claim 33 wherein means are provided whereby said sand remains in said further fluid bed section in said treatment temperature range without application of heat so as to continue reclamation utilising heat in said sand from the first fluid bed section.

35. An apparatus according to Claim 33 wherein said further fluid bed section is provided with heating means whereby said sand is maintained in said further fluid bed section in said treatment temperature range so as to continue reclamation partly by utilising heat in said sand from said first fluid bed section and with application of a lesser amount of heat than is applied in said first fluid bed section.

36. An apparatus according to any one of Claims 32 to 35 wherein the heating means comprises a plurality of heating elements immersible in the sand.

37. An apparatus according to Claim 36 wherein the heating elements comprise electrical heating elements.

38. An apparatus according to Claim 37 wherein the electrical heating elements comprise

electrical conductors in direct contact with the sand and through which electrical heating current at low voltage is passed, in use.

39. An apparatus according to Claim 36 wherein the heating elements comprise a combustion chamber and/or smoke tubes of a furnace in which fuel is burned, in use.

40. An apparatus according to any one of Claims 29 to 39 wherein the fluidising means comprises a plurality of discrete openings through which said combustion supporting gas is directed to the sand, said openings being provided with shield means to shield the openings from ingress of sand.

41. An apparatus according to any one of Claims 29 to 40 wherein means are provided to reduce the sand to grain size or substantially to grain size after separating said sand from said casting.

42. An apparatus for reclaiming used foundry sand substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

43. Foundry sand when reclaimed by a method as claimed in any one of Claims 1 to 20.

44. A metal casting when made by the method as claimed in any one of Claims 20 to 28.

45. Any novel feature or novel combination of features disclosed herein and/or shown in the accompanying drawings.

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